# Tech *Notes*

Self-Defense Distributed Engagement Coordinator

MIT Lincoln Laboratory helped develop a unique decision support tool that automatically evaluates responses to anti-ship threats and recommends actions to the personnel coordinating ship self-defense. This tool was recognized with a 2015 R&D 100 Award.

The U.S. Navy maintains the world's largest, most technologically advanced fleet of ships. Today, 272 naval vessels—ranging from huge aircraft carriers, amphibious assault ships, and cruisers, to heavy destroyers and frigates, to agile littoral combat ships, and to submarines—make up the full complement of deployable ships. The fleet's prime mission is to defend U.S. waters, borders, and military operations, but the fleet also supports rescue missions, disaster relief efforts, research operations, and global deterrence of maritime aggression. These ships are high-value assets; for example, the USS *Gerald R. Ford* aircraft carrier under construction now for a 2016 launch is projected to cost $13 billion. More than 325,000 well-trained officers, midshipmen, and enlisted sailors staff U.S. Navy ships. These ships, therefore, represent a significant investment of U.S. dollars and technical expertise, and protection of the fleet as it conducts missions vital to national security is a paramount concern for the U.S. Department of the Navy.

The Surface Navy Defense Challenge

The current proliferation and continual advancement of ballistic and cruise missiles have presented naval personnel with the problem of
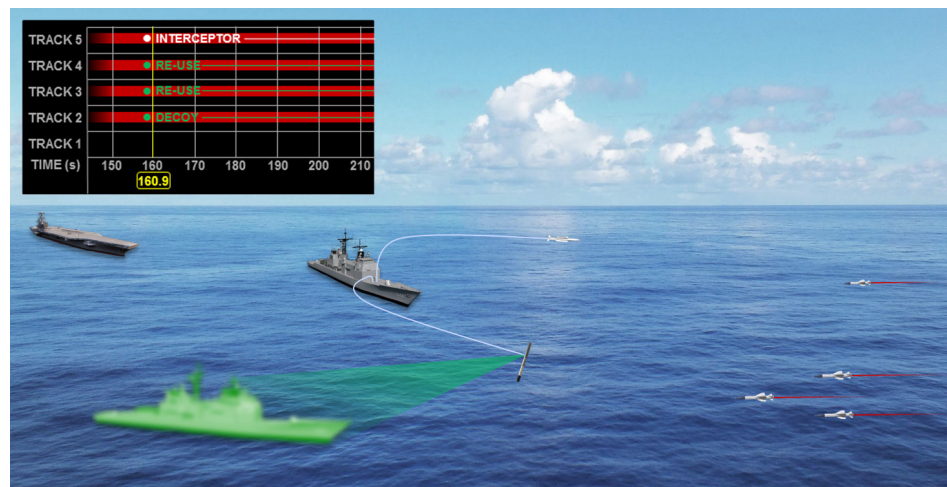
The Self-Defense Distributed Engagement Coordinator (SDDEC) is designed to provide automated battle management aids to operators who must decide the appropriate responses against missiles threatening U.S. naval assets. The SDDEC updates in real-time the engagement summary (inset) of the current threats and the weapons assigned to those threats. The engagement summary provides operators with guidance on the optimal assignment of defenses to maximize the survivability of the ships.

efficiently coordinating resources so that surface ships can survive a barrage of threats. Not only must the defense deploy countermeasures to anti-ship missiles, it must also manage the conservation of its countermeasures. Whether a missile is defeated with an interceptor, undermined by a signal jammer, or diverted by a decoy, there is

a cost, both financial and strategic, to expending countermeasures. Employing too many resources to respond to a missile threat may leave the ship without adequate protection from a subsequent attack. Re-arming a ship at sea is time-consuming, could put the ship in a vulnerable state during the reloading process, and may not be possible at all.

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A Technology Solution

MIT Lincoln Laboratory, in collaboration with the Office of Naval Research (ONR), has developed an automated decision support tool that will guide operators in appropriately selecting and effectively scheduling resources to combat missile threats. The Self-Defense Distributed Engagement Coordinator (SDDEC) is a software suite that manages heterogeneous weapon resources and makes intelligent decisions regarding their usage.

A novel algorithm allows the Self-Defense Distributed Engagement Coordinator to assess critical factors and recommend a response strategy that allocates resources to defeat incoming threats, while minimizing weapon usage.

The SDDEC is a highly customized system that meets the challenges of modern ship defense:

- Multiple U.S. ships equipped with various resources operate within a region. Any resource allocation to respond to a threat has to consider the locations and capabilities of the ships in proximity to the ship under siege.
- Because conditions during attacks change, ship defenders must alter their decisions to accommodate new variables, such as the appearance of more or different threats or the enemy's use of countercountermeasures. Thus, a viable decision support system must adjust dynamically to new situations.
- Today's communications capabilities enable rapid dissemination of information and quick reactions to evolving military engagements. Real-time operation is, therefore, necessary for the decision support tool to provide actionable instructions.

A novel algorithm allows SDDEC to assess a number of factors—ship and threat locations; the size of the ship's inventory of interceptors and decoys; interactions between ships, threats, and responses; and temporal and spatial variables—and then enables SDDEC to use the resulting assessment in recommending a strategy that allocates missiles and decoys for the defeat of an incoming threat while both increasing the probability that a ship will survive an attack and reducing weapons usage.

This algorithm was developed by casting resource allocation as an assignment problem. Combining its expertise in mathematical optimization solutions and ONR's understanding of naval defense tactics, Lincoln Laboratory researchers collaborated with scientists from the Operations Research Center at MIT's Sloan School of Management to apply modern computational techniques to the problem of calculating the risks and rewards associated with various response scenarios.

The resulting algorithm supports a real-time, distributed process:

> The SDDEC uses a ship's knowledge of the capabilities and costs associated with its own resources to develop an initial threat-response recommendation for the ship. The ship shares this recommendation with other fleet ships in the region. Using this information, the SDDECs on other ships update the plans for allocating the resources of these ships. As operators on various ships share information on the threat conditions and apprise each other of their plans, the SDDEC on each ship continues to dynamically make modifications to its recommendations. In this process, individual ships control their own engagements to meet local survivability or successful response thresholds while trying to cooperate with others to achieve fleet-wide objectives.

Impact of SDDEC

In today's netcentric environment, quick, accurate decisions are critical to fleet defense. SDDEC effectively provides automated decision support to personnel tasked with coordinating responses to anti-ship missiles because it

- Provides frequent updates for dynamic scenarios,
- Offers real-time operations,
- Can extend to large scenarios,
- Balances the use of valuable countermeasures against a ship's protection,
- Can calculate conservative and aggressive defense tactics as the need arises.

R&D Magazine selected this tool for one of its 2015 R&D 100 Awards. These international awards annually recognize 100 innovations that are judged to be technologically significant by a panel comprising technical evaluators and *R&D Magazine* editors.

The principles of SDDEC could be applied to customize automated allocation tools for other emergency responses. For example, the tools could guide the deployment of firefighting vehicles to locations most in danger during a wildland fire, direct border guards to vulnerable sites, or prioritize the distribution of medicine and medical supplies during an epidemic. ∎

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